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Distributive fairness: A mutual recognition approach

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ABSTRACT

Can norms of distributive fairness serve as pillars of a new and more effective global climate regime? Three general principles – responsibilities, capabilities (capacity), and needs (or rights) – are frequently invoked and rarely disputed. Yet, parties' interpretations often diverge, reflecting conflicts of interests. To determine how much is at stake, we compare – by means of a global integrated assessment model (GRACE) – 15 legitimate interpretations of 'responsibilities' and 'capabilities' in terms of their implications for the mitigation obligations and costs of seven potentially pivotal actors. Most of these interpretations yield similar results for most actors. In a scenario where global emissions in 2030 are reduced by 20% compared to a business-as-usual baseline, mitigation costs vary by less than 1% of GDP for the United States, the European Union, Japan, India, and China. For Brazil and Russia, however, variance is much larger. Moreover, for all actors, mitigation costs rise steeply as ambition levels increase. Under such circumstances, searching for a single 'fairness-optimizing' formula is likely to fail. As negotiators explore systems of voluntary pledges, a more promising approach would conceive of fairness as a multidimensional construct and foster accommodation through mutual recognition of a limited range of legitimate norm interpretations.

1. Introduction

Can norms of distributive fairness serve as pillars of a new and more effective global climate change regime? A positive answer requires that at least two conditions be met. First, a small set of compatible fairness principles and operational interpretations of these principles must be accepted as valid and relevant by a critical minimum of participating states. Second, these principles and interpretations must in fact serve as important premises for these states' policies and positions.

Good reasons for pessimism regarding both of these conditions are easy to find. Climate change mitigation combines several features that make it an extremely demanding governance challenge (Levin et al., 2012; Verweij et al., 2006; Victor, 2011). For many countries, large cuts in greenhouse gas (GHG) emissions are called for, requiring radical changes in important policies and practices. Very long time lags, many extending well beyond one human generation, exist between mitigation measures (involving more or less predictable costs for specific groups) and effects (in the form of more uncertain benefits for the world). Such time lags

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distort cost-benefit calculations by leaving important stakeholders disenfranchised and future benefits underrepresented. Stark asymmetries between rich (polluters) and poor (victims) generate severe conflicts of interest and 'dampen cooperative efforts' (Parks and Roberts, 2008, p. 621). In addition, strong competition in world markets and international politics tends to reinforce parties' concerns with *relative* gains and losses. Under such conditions, orchestrating effective cooperation would be a tall order for any intergovernmental organization. For the negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) – an institution combining universal participation with a very demanding decision rule (consensus) and a distribution of implementation power that tilts in favour of the major emitters – the challenge seems overwhelming.

One important implication of this sombre assessment is that searching for a common and precise formula that policymakers and diplomats can use to 'derive' a fair distribution of obligations and rights is not likely to succeed. In fact, intensive search for a single authoritative 'fairness-optimizing' formula may well *increase* the risk of deadlock (Bretschger, 2013; Parks and Roberts, 2008; Victor, 2011). Part of the explanation can be found in global conference diplomacy itself. Plenary sessions – in particular, those spotlighting political leaders – provide fertile ground for ideological posturing and for defending the interests of important domestic constituencies. Moreover, by establishing semi-permanent groups, the UN system 'may actually construct new lines of confrontation over and above the substance-based disagreements existing between countries' (Castro et al., 2014, p. 109). The risk of such counter-productive effects will likely increase further if a 'top-down' formula approach were to be pursued at a time when negotiations are turning towards 'bottom-up' pledges of voluntary contributions.

Yet, extant research strongly indicates that fairness matters, particularly when dealing with stark asymmetries between rich and poor (Dannenberg et al., 2010; Gampfer, 2014; Lange et al., 2010). The climate change challenge brings to the forefront profound questions concerning moral responsibility, mitigation and adaptation capacity, and people's rights to the global commons and to economic development. Although often invoked to legitimize and reinforce interest-based arguments and positions, norms of fairness can also serve to constrain the pursuit of self-interest and to provide roadmaps for accommodation (Dannenberg et al., 2010; Gampfer, 2014; Lange et al., 2010). Some analysts argue that for an international agreement to be effective it 'must be widely perceived as equitable' (Winkler and Rajamani, 2014, p. 103).

In this paper, we 'translate' the UNFCCC principles of responsibilities and capabilities into 15 allocation schemes and use a global integrated assessment model (GRACE, see Appendix) to explore the implications of these schemes for the mitigation obligations and costs of seven potentially pivotal actors: United States, European Union, Japan, Russia, Brazil, China, and India. We begin (Section 2) with briefly reviewing extant research to identify broadly accepted fairness principles and legitimate interpretations of these principles for the global distribution of mitigation obligations. In Section 3, we apply these interpretations to our seven actors under two alternative global emission reduction targets. We first explore the implications of the 15 interpretations for the relative distribution of mitigation obligations (Section 3.1) and move on to estimate each actor's costs of meeting its own obligations under the two global emission reduction targets (Section 3.2). In the final section, we explore the implications of these results for fairness-promoting strategies in the UNFCCC negotiations. Given the stark asymmetries between rich and poor and the consensus rule of the UNFCCC conferences, we argue that the most constructive contributions to a fair and effective agreement will likely come from actors who conceive of fairness as a multidimensional construct, recognize a limited range of norm interpretations as legitimate, and foster positive reciprocity through cooperative (more precisely, 'integrative') behaviour.

2. Fairness principles and operational interpretations

2.1. Norms and interests

In the research literature, three general observations stand out. First, even though a bewildering array of fairness criteria and arguments may seem to exist (see e.g. Klinsky and Dowlatabadi, 2009, pp. 97–98), the literature shows considerable convergence on a small set of basic principles. Second, parties' relative priorities and (operational) interpretations of these principles tend to reflect national circumstances and material interests (Carlsson et al., 2013; Lange et al., 2010). Not surprisingly, G77 estimates responsibility retrospectively – in some instances going back to the Industrial Revolution – while the United States attaches more importance to recent trends and likely future trajectories. Where some interpretations yield significantly higher mitigation costs than others, material interests will likely trump fairness norms. Third, the two sets of premises seem to *interact synergistically*, meaning (a) that parties tend to favour fairness principles and interpretations that are compatible with their own material interests, and (b) that any given principle and interpretation will likely be more important in reinforcing the positions of parties that stand to gain from their application than in modifying the positions of parties that expect to lose. Combining (a) and (b), we can see that in highly asymmetrical relationships, broad consensus at the level of general principles need not facilitate agreement on a specific deal (Underdal et al., 2012, p. 487). Accordingly, attention to the operational interpretation of norms is required to understand what parties can gain or lose.

In this paper, the term 'fair' refers to distributions that combine two key elements: equal treatment of equal cases (here: *equality*), and differential treatment of cases that differ significantly in important respects (here: *equity*). The latter requirement is most often translated into a somewhat flexible notion of *proportionality*. Sometimes, however, the range of variance is so wide that even a flexible interpretation of proportionality would leave the poorest or weakest parties with burdens they cannot reasonably be expected to shoulder. In such cases, a more categorical rule of *exemption* is often introduced, relieving certain parties (temporarily) of any

substantive obligations for which they are not adequately compensated. One important lesson emerging from this literature is that to qualify as fair, a climate agreement must *combine* notions of equality, proportionality, and exemption, as indicated in Table 1 (see Ringius et al., 2002).

In climate change negotiation documents and public statements, at least three interpretations of equity are frequently invoked and rarely disputed (see e.g. Mattoo and Subramanian, 2012). These interpretations refer to a party's *responsibility* for causing damage, its *capacity* to contribute to problem solving, and its *need* for (or *right* to) the goods or benefits concerned (Table 2). Responsibility is the backbone of the polluter-pays principle, capacity is the key differential variable in schemes of progressive taxation, and need is the most important criterion in social-welfare programmes. The UNFCCC reference to 'common but differentiated responsibilities and respective capabilities' (CBDR&RC), accepted by 195 states, is a fairly succinct expression of this three-pillar platform. In the climate change literature, no clear ranking has been established among these criteria, but a widely accepted interpretation seems to be that insofar as needs (rights) refer to *basic* goods or *fundamental* human rights, the needs (rights) criterion trumps the others (Müller and Mahadeva, 2013, p. 8). A survey targeting respondents directly involved in the climate change negotiations showed strongest support for the principles of responsibility (support balance = +69%) and need (support balance = +57%) (Lange et al., 2007).[1]

The question here is how alternative interpretations of the CBDR&RC principles of responsibilities and capabilities would affect important countries. We address this question first by exploring how countries' relative contributions vary with the exact interpretation of these principles, and second by estimating the impact of countries' relative mitigation contributions on their national welfare, under two global ambition levels. To render these tasks manageable, the analysis is limited to seven key actors: Brazil, China, the European Union, India, Japan, Russia, and the United States. Together, these actors account for nearly two thirds of world GHG emissions (including LUCF). Moreover, most are seen as leaders of larger groups of countries (Karlsson et al., 2011), indicating that any mitigation agreement signed and ratified by all seven will likely be accepted by a large majority of other states as well.

2.2. *Interpretations of responsibility*

Normative theory distinguishes between an actor's role in causing damage and that actor's moral responsibility ('guilt') for the damage it has caused. A causal role is a necessary but not a sufficient condition for moral responsibility. To assign moral responsibility, one must in addition prove that an actor (a) had, or at least could have obtained, effective control over the harmful activities for which it stands accused, and (b) knew, or at least could reasonably be expected to have known, the (risk of) damage caused by these activities (see e.g. Aristotle, 350 BCE; Müller et al., 2009). The control requirement limits the transferability of guilt across generations.[2] The available knowledge requirement implies that the historical backlog of moral responsibility cannot go back to the Industrial Revolution, beginning around 1760. Most of the research literature seems to agree that there developed around 1970 a sufficiently solid and well-known scientific basis for suspecting human activities of being a significant driver of climate change (Mattoo and Subramanian, 2012, p. 1088); to be on the safe side, some say compelling evidence has been available 'at least [...] since 1990' (Parikh and Parikh, 2009, p. 4), the year the first IPCC assessment report was published.

Table 1 – Fairness principles and their validity domains.

Fairness principles	Validity domains
Equality	Relevant differences too small to be normatively significant
Equity – proportionality	Relevant differences normatively significant but not very large
Equity – exemption	Relevant differences very large

Note: Builds on Ringius et al., 2002.

What may legitimately be traced back to early periods of technological innovation and economic growth are *accumulated competitive advantages* enjoyed also by current generation(s). Particularly relevant to the climate change negotiations are persistent advantages and benefits accumulated through unrestricted use of Earth's capacity to absorb GHG emissions. This capacity is a global collective good, overexploited by the rich North to its own advantage. The world's poor, many being innocent victims of climate change, can make a strong case for equal opportunities or adequate compensation (Baer, 2013). One way of recognizing the equal-opportunities claim would be to include competitive advantages accumulated by the rich North through unrestricted use of global commons as integral elements of *capabilities* (implying higher mitigation obligations for the North) and *needs/rights* (implying lower mitigation obligations for the South).

To apply the responsibility principle to climate change mitigation, further specification is required in at least three respects. First, *which GHGs* and human activities should be included in responsibility assessments (see den Elzen et al., 2013)? Since the human impact on the climate system is a function of the weighted aggregate of all GHG emissions generated by human activities, the default option would be an equally comprehensive responsibility estimate. Practical problems of emissions accounting and impact measurement may, however, lead parties to settle for a less comprehensive programme. Hence, this analysis considers two notions of comprehensiveness: CO_2 emissions from fossil fuels only and total emissions of GHGs.

Second, who qualifies for *exemption*? In the research literature, the most common approach has been to grant exemptions to countries whose average income level falls below a certain (official) poverty line (e.g. Baer, 2013; Müller and Mahadeva, 2013). Since even poor countries have rich

[1] The support balance is measured as (very high + high support) – (low + very low support). In the survey, the responsibility principle was labelled 'polluter pays' and the need principle 'poor losers'.

[2] For more or less permanent organizations, such as states, this limitation may be modified but not dismissed.

Table 2 – Common interpretations of equity.

Focus on	Object to be allocated	
	Costs (obligations)	Benefits (rights)
Causes of the problem	*Responsibility* (moral responsibility/'guilt' in having caused the problem)	*Previous contributions* (to solving the problem)
Consequences of the solution (efforts)	*Capabilities* (capacity to contribute to problem solving)	*Need* for (or right to) the goods concerned

Notes: Builds on Ringius et al. (2002). The 'previous contributions' argument is the least frequently invoked and therefore not considered here. 'Need' is often operationalized as the inverse of GDP per capita, the most common indicator of capabilities, and – as such – included here.

people and rich countries have poor people, some have argued that the domestic distribution of income or wealth should also be taken into account (e.g. Rao, 2013). The analysis reported here applies the following exemption rules: Countries with per capita CO_2 emissions above the world average (here: United States, European Union, Japan, and Russia) have proportional responsibility for all their own emissions. Countries emitting between 50% and 100% of the world average (here: China and Rest of the World) are proportionally responsible for emissions within that interval only. Countries emitting <50% of the world average (here: Brazil and India) are granted full exemption.

Third, for which *time horizon* should responsibility be estimated (see Friman and Hjerpe, 2014)? The scope conditions of control and knowledge limit the backlog of moral guilt but provide no guidance regarding likely future emission trajectories. What can be said, however, is that dynamic updating would be required to capture significant changes in countries' shares of global emissions. For CO_2 emissions, four partly overlapping time horizons are considered (1971–2009, 1990–2009, 1971–2017, and 1990–2017); for all GHGs, only the 1990–2010 period is included.

Some recent studies have made a case for replacing conventional emissions accounting with estimates that also capture the carbon embodied in international trade (see e.g. Peters et al., 2012). Other studies have argued that since responsibilities and capabilities vary substantially within countries, the appropriate level of analysis would be individuals or households rather than countries (see e.g. Kartha et al., 2012). Three of our allocation schemes are designed to explore plausible implications of these arguments for the global distribution of mitigation obligations.

2.3. *Interpretations of capabilities*

Strictly speaking, capabilities can be assessed only with reference to a specific task or function. Thus, some factors important in boosting mitigation capacity – renewable energy resource endowments, for example – are less important for adaptation. Moreover, a country's contribution to mitigating GHG emissions may take different forms – from preserving or establishing sinks to transforming carbon-intensive energy systems – and the capabilities required will somewhat depend on the kind of contribution made. Confronted with such complexity, researchers (and policymakers) have looked for a simple capabilities concept that can cover a wide range of tasks and functions. 'Capacity to pay' seems to meet this requirement at least as well as any other equally simple conceptualization, and GDP per capita has emerged as a broadly accepted indicator for which standardized data are readily available. Refinements have been suggested, however. Among these the Oxford Capabilities Measure stands out as a strong candidate, combining national GDP and GDP per capita figures with an index of 'poverty intensity' (Müller and Mahadeva, 2013). Some researchers find the capacity-to-pay framework too narrow and point to more inclusive multidimensional constructs, in particular the UNDP's Human Development Index (Winkler et al., 2013, p. 413). The argument has merit; some important capability components – renewable energy resource endowments being one obvious example – are not at all represented by the GDP per capita indicator. Moreover, important tasks, such as de-carbonizing energy systems, call for capacity to innovate and govern, not merely capacity to pay.

In response to objections raised against relying on GDP per capita as the only indicator of relevant capabilities, two more inclusive indexes are constructed. One, labelled *transformation capacity*, is designed to measure countries' economic and political abilities to 'de-carbonize' energy systems. As defined here, transformation capacity is a function of (a) the conventional GDP per capita variable (weight .6), (b) innovation capacity (.2), (c) governance capacity (.1), and (d) transparency (.1). The other index, labelled *renewable energy resource endowments*, is a weighted aggregate of countries' per capita endowments of solar (.4), wind (.2), bio (.2), and hydro (.2) energy resources.[3]

To sum up, we have translated the UNFCCC principles of responsibilities and capabilities into 15 allocation schemes, of which 11 are interpretations of responsibilities and four are interpretations of capabilities. Table 3 provides a brief overview of these schemes; more information is provided in the online supplementary material.

2.4. *Scenarios for assessment of mitigation costs*

To estimate mitigation costs of alternative distributive schemes we need to specify mitigation targets (ambition levels). In this analysis, global mitigation targets are determined on the basis of a business as usual (BAU) scenario by using a global economic model (GRACE) briefly described in the Appendix. We construct a BAU scenario, where population growth follows the 2010 version of the United Nations projection (UNPD, 2011). The BAU scenario roughly reproduces the regional GDP growth 2010–2030 as depicted in the New

[3] Some of the estimates of renewable energy resource endowments do not meet strict standards of comparability, so caution is required in interpreting the results.

Table 3 – Two fairness principles and the 15 interpretations examined in our analysis.

Fairness principle	Interpretations	Operational specifications
Responsibilities	Total CO_2 emissions from fossil fuels: *four* interpretations, ref. to alternative time horizons	Time horizons: 1971–2009; 1990–2009; 1971–2017; 1990–2017
	Per capita emissions of CO_2 from fossil fuels: *four* interpretations, ref. to alternative time horizons	As above
	Total CO_2 emissions, including carbon embodied in int. trade: *two* interpretations, ref. to alternative time horizons	Time horizons: 1990–2010; 1990–2017
	Total emissions of all greenhouse gases (in CO_2 equivalents): *one* interpretation	Time horizon, 1990–2010
Capacities	Energy systems' transformation capacity: *one* interpretation, weighted aggregate (index)	Index weights: GDP/capita (.6), innovation (.2), governance (.1), transparency (.1)
	Domestic distribution of individual wealth (adults only): *one* interpretation	Index distinguishing four levels of wealth, weighted 0 (<1000 USD) to 5 (>100,000 USD)
	Renewable energy resource endowments per capita: *one* interpretation, weighted aggregate (index)	Index weights: Solar (.4), wind (.2), bio (.2), hydro (.2)
	Renewable energy resource endowments per capita + GDP/capita: *one* interpretation	Index weights: Renewables/capita (.5), GDP/capita (.5)

Note: For additional information, see supplementary material, TABLES SM1–5.

Policies Scenario of World Energy Outlook 2010 (IEA, 2010). Growth of CO_2 emissions from fossil fuels follows total GHG emissions in the reference scenario of the Climate Action Tracker (2012) by assuming a constant share of CO_2 emissions from fossil fuels in total GHG emissions. That share is also used to derive CO_2 emissions from fossil fuels in other scenarios.

Besides the BAU scenario, we consider two mitigation scenarios of the Climate Action Tracker (2012): Scenario 1 representing the 'More ambitious proposals & national policies not yet pledged internationally' and Scenario 2 depicting an 'Illustrative pathway likely holding warming below 2 °C'. For both scenarios, we derive global CO_2 emissions from fossil fuels 2010–2030 (Fig. 1a). To achieve global CO_2 reductions in 2030 by 20% and 50% of the BAU levels in Scenarios 1 and 2, respectively (Fig. 1b), we assume a global carbon market where regional CO_2 prices are equalized through interregional carbon trade. This global market mechanism moves CO_2 prices towards US$60 and US$340 per tonne in Scenarios 1 and 2, respectively (Fig. 1c), reflecting that marginal costs of CO_2 reduction increase markedly along with tighter mitigation targets. Because the GRACE model assumes an ideal world in the sense that barriers are absent, the cost-effective regional 'real' emissions (Fig. 1d) can always be achieved no matter which distributive scheme is selected (see e.g. Hoel, 1991). In doing so, we isolate the effect of a distributive scheme on regional mitigation costs.

In this analysis, we use GDP changes compared to BAU to indicate mitigation costs of the two scenarios and of alternative distributive schemes.

3. Results and discussion: how much is at stake?

3.1. Fairness in terms of relative contributions to global mitigation

Fig. 2 and Table 4 summarize the results regarding relative contributions to global mitigation efforts. Four patterns emerge as quite robust. First, for *all* indicators of responsibility and transformation capacity, rich countries must contribute much more to mitigating climate change than poor countries do. Second, the distance between rich and poor countries is smaller for all capabilities-based indicators (except GDP per capita) than it is for emissions-based indicators of responsibility. The difference between these two sets of indicators reflects technological development and changes in the world economy over the past three to four decades. Third, overall, responsibilities measured in terms of emissions are not much affected by the choice of time horizon (Spearman rho = .94**–1.00**) or scope of comprehensiveness (.86*–.96**). Similarly, within our sample of actors, all transformation-capacity indicators are strongly correlated with each other (.71*–.96**) and the aggregate index itself correlates positively with responsibilities measured as per capita CO_2 emissions (.82*–.86*). The only striking exception to this pattern is the renewable energy resource endowments index, which adds a truly different dimension so far ignored in most capability assessments. Fourth, for all actors except India, one or two of our indicators deviate significantly from the prevailing pattern, and for Brazil and Russia differences in mitigation costs are large.

This analysis leaves us with three important messages. First, most interpretations examined here yield similar results for most but not all actors. Some policy implications of fairness principles seem, in other words, to be broadly accepted. Second, no single indicator can represent all legitimate interpretations of the principles of responsibilities and capabilities. Third, no single dichotomy – such as that between 'rich' and 'poor', or 'developed' and 'developing' – can adequately capture the full range of variance on responsibility and capability indicators found among the countries participating in the UNFCCC negotiations.

3.2. Fairness in terms of mitigation costs

Here, three observations stand out. First, marginal mitigation costs rise steeply for all parties (regions) as overall ambitions increase (Fig. 3). In Scenario 1, mitigation costs for the

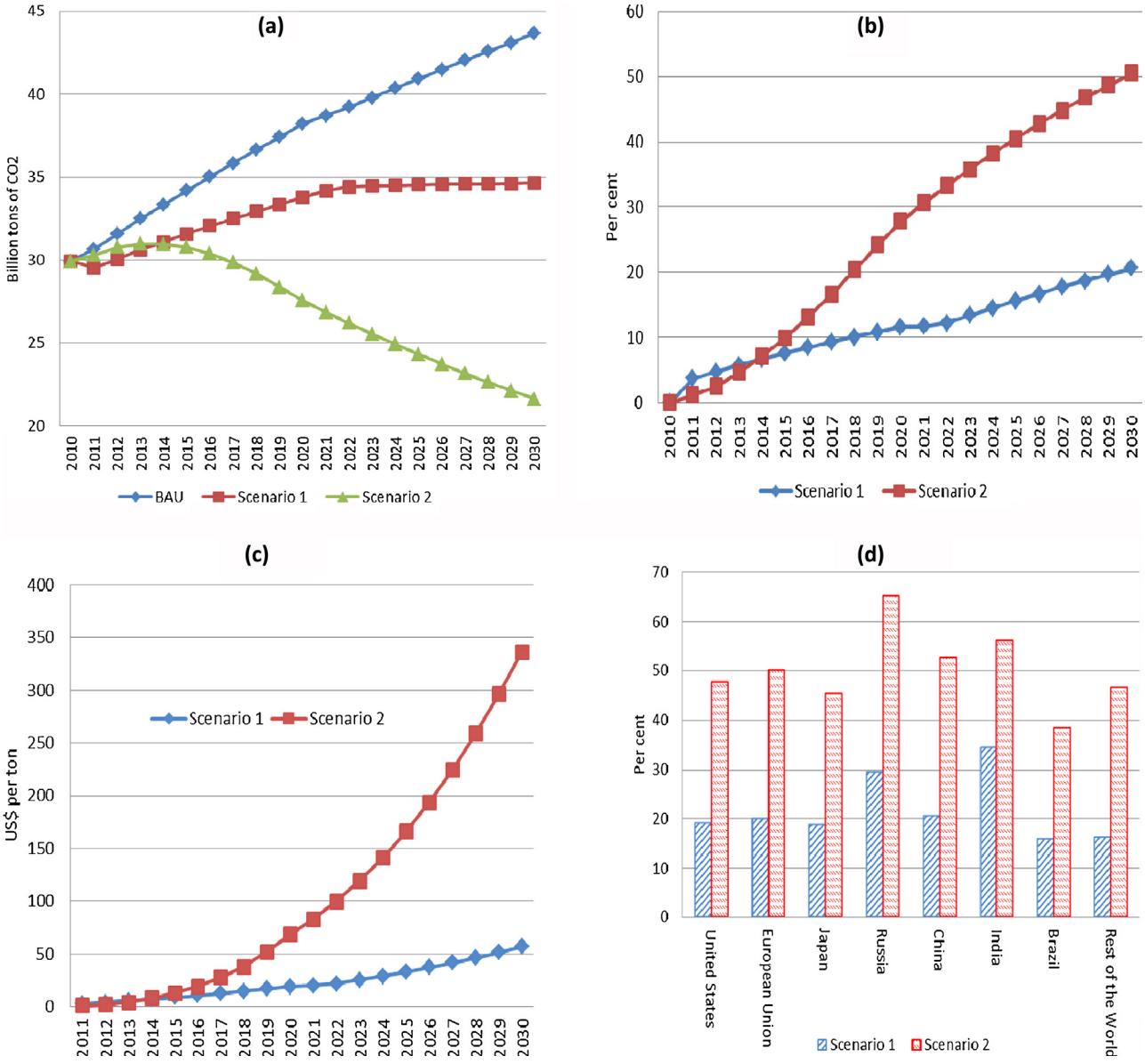

Fig. 1 – Global mitigation scenarios: (a) Global CO_2 emissions from fossil combustion, (b) global mitigation targets of CO_2 emissions compared to BAU, (c) global CO_2 prices, and (d) 'real' CO_2 reductions in 2030 compared to BAU.

European Union, the United States, Japan, and China are, for all principles and operational interpretations, within the range of 1% of GDP. In Scenario 2, corresponding figures for these parties are about 10 times higher. This dramatic increase is not visible in the responsibility- and capability-based estimates of countries' relative contributions shown in Fig. 2. The increase is, however, profoundly important for the climate change negotiations, making a new global agreement at the Scenario 2 level much harder to reach – and even more so to implement – than an agreement at the Scenario 1 level would be.

Second, in both scenarios, mitigation costs vary considerably among parties, consistent with patterns found in other studies (e.g. Mattoo and Subramanian, 2012). Among developing countries, India benefits under all principles and interpretations, and China benefits from some interpretations but only in Scenario 2. By contrast, Brazil risks considerable losses in both scenarios. Substantial differences are found also within the group of developed countries. In both scenarios, the United States, the European Union, and Japan suffer only modest losses compared to Russia, which consistently stands out with the highest relative mitigation costs of all seven parties. Russia's vulnerability is due to its heavy dependence on fossil fuel extraction. Worth noticing, our analysis indicates that mitigation costs can vary as much *within* the groups of 'developing' and 'developed' countries as between these groups.

Third, in the less ambitious Scenario 1, four parties – China, India, the European Union, and the United States – are only moderately affected by the choices examined here among fairness principles and interpretations. For the other three parties, mitigation costs vary much more. In our sample, Brazil provides the most dramatic illustration, with deviations in GDP ranging from −0.6 to −4.0% of BAU in Scenario 1 and from

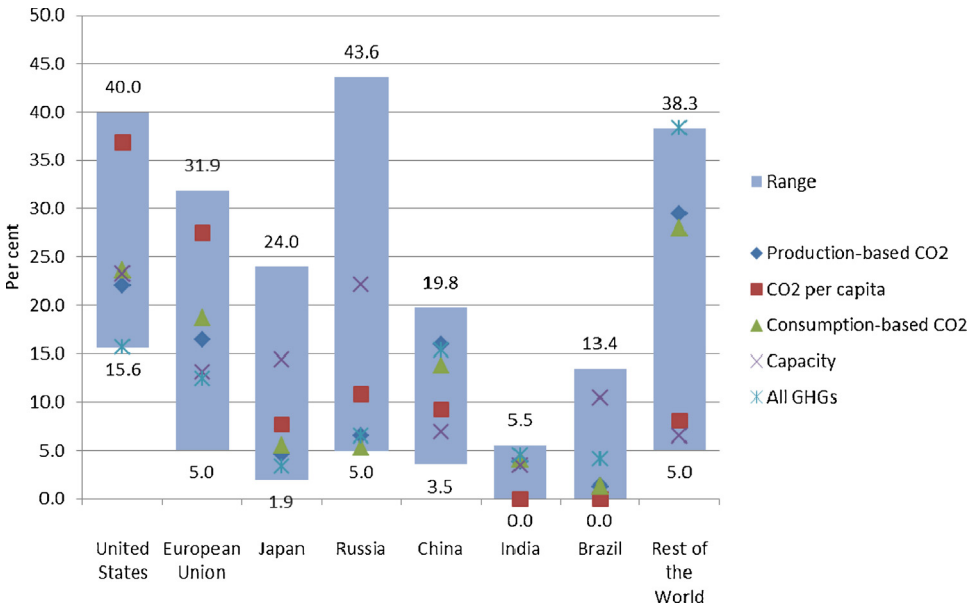

Fig. 2 – Regional contributions to global mitigation as percentage of the world total. *Note:* The numbers above the bars show the maximum shares and the numbers below show the minimum shares. The discrete points are mean shares of corresponding subgroups. Details of the distribution of contributions to global mitigation are provided in Table SM-1 in the Online Supplementary Material.

−1.8 to −30.5% in Scenario 2. These huge differences are because Brazil qualifies for exemption by responsibility measured in terms of CO_2 emissions but scores (much) higher on most capabilities indicators. Large differences can be expected also for other developing countries that qualify for full exemption by (some) responsibility criteria but that have at least some of the capabilities required to contribute to mitigation. Overall, exemption rules are critical determinants of obligations and costs.

4. Conclusion: outlining a 'mutual recognition' approach

Our analysis shows that the fairness principles of responsibilities and capabilities yield similar results for most actors, at least in Scenario 1, but not for all. It furthermore shows that although most operational interpretations of each principle correlate positively, no single indicator can represent all legitimate interpretations of either principle. These findings have important implications for the role(s) that norms of distributive fairness can play in the UNFCCC negotiations. Given the stark asymmetries existing between rich and poor, the amount of control that major emitters have over emission cuts, and the UNFCCC system's limited capacity to integrate and aggregate divergent preferences (Keohane and Victor, 2011), search for an integrated 'fairness-optimizing' formula may well increase the risk of deadlock. What the UNFCCC negotiations seem to need as attention turns towards bottom-up announcements of voluntary contributions (Kallbekken et al., 2014; Rietig, 2014) is a more ecumenical approach that can help parties build agreement on diversity and foster positive reciprocity through cooperative behaviour.

Table 4 – Operational specifications of norm interpretations giving the lowest and the highest mitigation obligations (and costs) for each country.

Actor	Lowest obligations/costs	Highest obligations/costs
United States	R: all GHG emissions, 1990–2010	R: CO_2 emissions per capita, 1971–2009
European Union	*C: renewable energy endow. per capita*	R: CO_2 emissions per capita, 1971–2009
Japan	*C: renewable energy endow. per capita*	*C: individual wealth*
Russia	R: CO_2 1990–2017, total consumption	*C: renewable energy endow. per capita*
Brazil	*R: CO_2 emissions per capita (exemption)*	C: renewable energy endow. per capita
China	R: CO_2 emissions per capita, 1971–2009	R: CO_2 total emissions, 1990–2017
India	*R: CO_2 emissions per capita (exemption)*	R: CO_2 1990–2017, total consumption

Note: R indicates responsibilities, C capabilities. Italics mean that this score differs substantially from the scores observed for *all* other indicators for this particular actor (by a factor <5 for the 'lowest' column, or a factor >2 for the 'highest' column). Total consumption includes also carbon embodied in international trade.

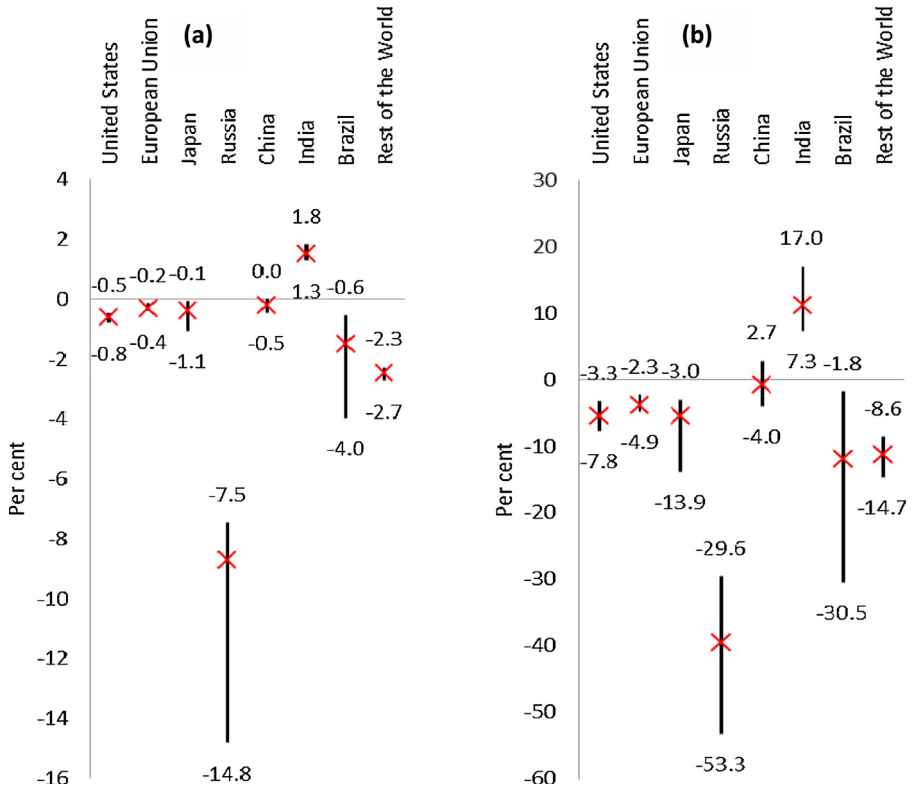

Fig. 3 – Deviations of GDP from BAU in 2030: (a) Scenario 1 and (b) Scenario 2. *Note*: The vertical lines show the ranges of the deviations for the distributive schemes of each scenario and the "X"s show the simple average of deviations in the 15 cases. The most positive deviations are shown above the lines and the most negative below. Details of the regional mitigation costs are provided in Table SM-6 in the Online Supplementary Material.

A mutual recognition approach is designed to do just that. It does so by narrowing the range of legitimate principles and interpretations in accordance with the guidance provided by normative theory. In addition, the approach builds on two principal insights of social science research. One, pioneered by Simon (1947), says that in dealing with complex problems, decision-makers usually adopt a technique of (sequential) satisficing rather than (synoptic) optimizing. Applied to the UNFCCC negotiations, this insight suggests that fairness principles and interpretations may best be understood as *filters* blocking 'unfair' options. The other insight says that concerns with fairness and legitimacy apply not merely to the outcome but also to procedure and behaviour (e.g. Rawls, 1971). In fact, a recently published study of international trade negotiations (Albin and Druckman, 2014, p. 1) finds that '[T]he correlations between procedural justice and effectiveness are very strong, and significantly stronger than between distributive justice and effectiveness'. This is an important reminder that mutual trust and respect must sometimes be grown and that the process may take years of patient and careful cultivation. The core of the mutual recognition approach is a set of *behavioural rules* that may help parties do so.

The first and most fundamental rule calls upon all parties to accept a small *set* of basic fairness principles, and a limited *range* of interpretations of each of these principles, as legitimate premises for an international agreement. 'Legitimate' here means broadly consistent (a) with the Framework Convention's CBDR&RC platform, and (b) with the guidance provided by relevant normative theory, as summarized in Section 2. Taken together, this set of principles and interpretations may serve as a common and somewhat elastic framework for working towards a distribution of commitments that recognizes '… the simultaneous presence of multiple valid, and sometimes conflicting ways, of framing a problem' (Brugnach and Ingram, 2012, p. 61).

Second, in determining which principles and interpretations to accept as legitimate, parties apply a standard of *reciprocity*. In this context, reciprocity implies (a) acceptance that any fairness principle – and any interpretation of such a principle – that a party advocates may legitimately be invoked by any other party, and (b) recognition of any other principle or interpretation that a party would likely have supported had it found itself in circumstances similar to those of the party invoking that principle or interpretation. According to requirement (a), anyone claiming, for example, a right to development must grant the same right to all others, including previous and future generations. According to (b), parties must admit that their own conceptions of fairness are to some extent influenced by self-interest and allow others to be similarly self-interested. These kinds of reciprocity rules may be refined by, for example, granting parties the right to claim exemption from an indicator that yields a *particularly* unfavourable outcome, far outside the range defined by other indicators (see Table 3). Conversely, parties may agree to

constrain reliance on single indicators that yield exceptionally positive outcomes. Such rules will likely be controversial but – if supported by conference presidents, committee chairs, and external review panels – they can at least call attention to important questions of reciprocity and help parties acknowledge their own biases.

Third, in assessing alternative conceptions of distributive fairness, parties recognize that they all operate under *feasibility constraints*, political as well as technological and economic. Only measures that pass all these constraints can be effectively implemented. Moreover, as stalemate continues, parties face an evermore pressing dilemma between fairness and effectiveness: insisting on immediate and 'perfect' equity will almost certainly lead to GHG emissions well above the threshold IPCC considers prudent to avoid 'dangerous anthropogenic interference with the climate system' (UNFCCC, Article 2). Mutual recognition of feasibility constraints may help parties see merits in constructive exploration of agreements involving *change* in relative contributions over time.

Fourth, since some parties' scores on capabilities as well as responsibilities criteria change over time, a *dynamic* agreement including provisions for regular updating will have significant advantages over static arrangements. Whatever its merits at the time of its invention, the frozen dichotomy between Annex I countries and the rest of the world is becoming increasingly inadequate as an expression of present and future variance in responsibilities, capabilities, and needs.

Finally, we make no claim that the approach outlined above will *always* be more effective than a formula approach will be. Clearly, once agreed, a single formula can provide guidance that is more precise. Moreover, as the European Union experience indicates, a formula approach has a fair chance of being adopted and successfully implemented where (a) the group of parties is fairly small and homogeneous, (b) the organization serving this group has high institutional capacity, (c) the implementation power balance tilts in favour of enthusiasts, and (d) the problem itself scores low on political-malignancy scales. Our main arguments are (a) that UNFCCC negotiations occur in a very different and much more demanding setting, and (b) that because they increasingly turn towards individual pledges of emission reduction targets and measures, a 'matching' approach is needed to bring principles of procedural and distributive fairness to serve as premises for formulating and assessing pledges. The mutual recognition approach is designed specifically for such highly demanding settings where mutual trust and understanding must be cultivated and confirmed through fair procedures and cooperative behaviour vis-à-vis other parties (see Lejano and Fernandez de Castro, 2014).

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Appendix A. The GRACE model

This study uses a multi-sector, multi-regional, recursively dynamic global computable general equilibrium model GRACE (Aaheim and Rive, 2005). GRACE stands for the Global Responses to Anthropogenic Change in the Environment. The model has been applied to studies on climate impact, adaptation, mitigation, and related policy analysis (e.g. Aaheim et al., 2012; Eskeland et al., 2012; Glomsrød et al., 2013; Rypdal et al., 2007).

This version of GRACE divides the world into 8 regions: United States, European Union, Japan, Russia, China, India, Brazil, and the Rest of the World. The regional economy includes 15 production activities (Table 3, Glomsrød et al., 2013). The model is calibrated around the GTAP v7 database, with 2004 as a base year (Badri and Walmsley, 2008).

In a region, the exogenous endowments of productive resources (i.e. labour, capital, and natural resources) are fully used for production in a year. Labour can flow freely from one activity to another, whereas capital and natural resources are activity-specific. Producers pursue profit maximization and consumers pursue utility maximization. Bilateral trade allows substitution among regional contributions. Regional income includes the remuneration for productive resources and taxes. Savings as a fixed share of income are used for investments such that the changes in rates of return on capital are equalized for all regions. The new capital formed from the investment and capital depreciation in a region is allocated to activities such that their rates of return are equalized. The capital existing at the beginning of the previous year is activity-specific.

Economic growth is mainly driven by savings and investments, but is also determined by population growth, change in the availability of natural resources, and technological change. The regional rates of technological change are the same for all simulation cases.

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2015.03.009.

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